Ztek's Ultra-High Efficiency Fuel Cell/ Gas Turbine Combination

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Ztek is proceeding on development of an ultra-high efficiency hybrid system of its Planar SOFC with a gas turbine, realizing shared cost and performance benefits. The gas turbine as the Balance-of-Plant was a logical selection from a fuel cell system perspective because of: 1) the high-power-density energy conversion of gas turbines; 2) the unique compatibility of the Ztek Planar SOFC with gas turbines; and 3) the availability of low-cost commercial gas turbine systems. A Tennessee Valley Authority/Ztek program is ongoing, which addresses operation of the Advanced Planar SOFC stacks and design scale-up for utility power generation applications.

The advanced SOFC Fuel Cell/Gas Turbine hybrid approach discussed here is potentially capable of reaching electrical **efficiencies above 70%(LHV), or heat rate of less than 4800 BTU/kWh (LHV)**. This alternative has the distinct advantage of being applicable over a wide range of plant capacities, from sub-MW to multi-MW. Ztek's planar SOFC, which operates at 1000˚C, has patented features which enhance direct integration with a gas turbine. This approach is based upon applying Ztek's Planar ATI¿ SOFC as a **C**ombustor **A**nd **R**ecuperator Replacement for **A**dvanced **T**urbine **S**ystem (**CARR-ATS**). The SOFC will replace the combustor section, and displace the need for a recuperator for efficiency enhancement. Integrating Ztek's patented technology, therefore, can provide increased system efficiency and capacity with reduced NOx emissions.

The incentives and justification for the pressurized operation of the Ztek Advanced SOFC and integration with gas turbine bottoming systems are summarized below:

- The SOFC has **physically and chemically stable** electrolyte and electrodes which do not suffer adverse effects under pressurized operation.

- Ztek's Planar SOFC Technology is fully compatible with operation at ambient or elevated pressure conditions. The planar cell is **structurally compatible with operating at high pressures**, and tolerant to a finite pressure difference between opposing reactants, due to the mechanical design, materials, and the small free span chosen for the ceramic electrolyte supports.

- The pressurized operation of Ztek's Planar SOFC with its internal manifolding of controlled piping size will allow **high capacity module** integration.

- The performance of a fuel cell stack integration can increase with pressure due to favorable Nernst potential and enhanced flow uniformity at high pressure, resulting in **higher power density**. This further enhances the compactness and cost advantage in considerations of both the fuel cell stack, reactants piping and the pressure vessel designs.

- Ztek's Planar SOFC design permits internal thermal management, resulting in a **high temperature exhaust gas** suitable for input to the integrated gas turbine. This is a significant benefit compared to other fuel cell designs which require external heat recovery and invariably reduce the exhaust temperature to a level too low to be useful.

In conclusion, the gas turbine represents a cost effective resource for the Balance-of-Plant in the fuel cell system, because of its energy conversion performance and the availability as off-the-shelf equipment. The advanced thermal integration features of the Ztek Planar SOFC uniquely facilitate the hybrid system integration with a gas turbine. With the hybrid system integration, the Ztek Planar SOFC and gas turbine can mutually enhance the favorable characteristics of cost, efficiency, package flexibility, and environmental performance.

Studies of near-term applications of Ztek's SOFC technology, by year 2000, indicate that systems in the capacity range of sub-MW to 10MW offer ultra efficiency of more than 70% for pressurized SOFC/Gas turbine systems. Ztek plans to provide Distributed Generation products to customers at a system price below $900/kW. It is expected that the Cost-of-Energy of these units will approach 4 Cents/kWh.

The Ztek Planar Solid Oxide Fuel Cell Technology has been developed under cost sharing of corporate funds and contracts with the Tennessee Valley Authority, the Electric Power Research Institute, the U.S. Department of Defense and the U.S. Department of Energy.